费曼3作业2

郑子诺，物理41

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71.4

(a)Because the photons are Bosons,we have:

$$P_{emission} = |\langle n+1|n\rangle|^2 = (n+1)P_0$$

$$P_{absorption} = |\langle n-1|n\rangle|^2 = nP_0$$

The emission and absorption build an equilibrium:

$$N_2P_{emission} = N_1P_{absorption}, N_1P_{emission} = N_0P_{absorption}$$

$$\therefore \frac{N_2}{N_1} = \frac{N_1}{N_0} = \frac{n(\omega)}{n(\omega)+1}$$

(b)Use Boltzmann distribution we have:

$$\frac{N_2}{N_1} = \frac{N_1}{N_0} = e^{-\frac{\Delta E}{kT}}$$

$$\therefore n(\omega) = \frac{1}{e^{\frac{\Delta E}{kT}} - 1}$$

(c)

$$\hbar\omega \gg kT, n(\omega) \approx e^{-\frac{\hbar\omega}{kT}}$$

$$\hbar\omega \ll kT, n(\omega) \approx \frac{kT}{\hbar\omega}$$

71.6

(a)Because the stimulated emission produces photons at exactly the same state as the one induces,the direction of the photons is obviously the same.

(b)Impossible.Because neutrinos have spin of one-half that they are fermions,they couldn't be the same state as a result of Pauli exclusion principle.

71.9

(a)The recoil breaks up the nucleus,which distinguishes the one proton interacted.Therefore the probability is:

$$P(\theta) = P_1|f_1(\theta)|^2 + P_2|f_2(\theta)|^2$$

(b)The nucleus remains intact,which means the final states of two kinds of scattering are the same.Hence the probability is:

$$P_(\theta) = |\sqrt{P_1}f_1(\theta)+\sqrt{P_2}f_2(\theta)|^2 = P_1|f_1(\theta)|^2+\sqrt{P_1P_2}(f_1^*(\theta)f_2(\theta)+f_1(\theta)f_2^*(\theta))+P_2|f_2(\theta)|^2$$

The phase of the probability amplitude of P_1, P_2 is absorbed in $f_1(\theta), f_2(\theta)$.

(c)The probability of the case in (b) have an interference term,which is probably positive and gives more scattering,otherwise it gives less scattering.

71.11

(a)Because the velocity of proton in center-of-mass system is the same as the velocity of center-of-mass,we have

$$\alpha = \frac{\theta}{2}$$

(b)Obviously it's

$$g(\theta) - f'(\pi - \theta)$$

(c)The scattering probability of up-up and down-down is

$$2|f(\theta) - f(\pi - \theta)|^2$$

The scattering probability of up-down and down-up is

$$|f'(\theta) - g(\pi - \theta)|^2 + |g(\theta) - f'(\pi - \theta)|^2$$

Because the probability of each case is $\frac{1}{4}$,we have:

$$P(\theta) = |f(\theta) - f(\pi - \theta)|^2 + \frac{1}{2}(|f'(\theta) - g(\pi - \theta)|^2 + |g(\theta) - f'(\pi - \theta)|^2)$$

(d)Simplify the result of (c) we have

$$P(\theta) = |f(\theta)-f(\pi-\theta)|^2+\frac{1}{2}(|f(\theta)|^2+|f(\pi-\theta)|^2) = \frac{5}{4}|f(\theta)-f(\pi-\theta)|^2+\frac{1}{4}|f(\theta)+f(\pi-\theta)|^2$$

(e)

$$A = \frac{5}{4}, B = \frac{1}{4}$$